Claims

1. An apparatus comprising a first chamber and a second chamber and a membrane which divides the first and second chambers; the membrane comprising a support and a catalyst;
the membrane being adapted to allow passage of a first reactant from the first chamber to the second chamber through said membrane;
wherein the first reactant is imparted with enough energy by the catalyst upon said passage so as to react with the second reactant.

2. Apparatus as claimed in claim 1, wherein the support is adapted to operate at temperatures exceeding 250°C.

3. Apparatus as claimed in claim 2, wherein the support comprises an inorganic support.

4. Apparatus as claimed in any preceding claim, wherein the support comprises pores and there is a graduation in the average pore radii towards one surface of the support.

5. Apparatus as claimed in any preceding claim, wherein the membrane is adapted to activate molecules of the first reactant without forming an ionic species before the reaction with the second reactant.

6. Apparatus as claimed in any preceding claim, wherein the support comprises a layer with a roughened surface which has an increased tortuosity compared to the tortuosity of the rest of the support.

7. Apparatus as claimed in claim 6, wherein the relatively roughened surface is provided on an outer surface of the support.

8. Apparatus as claimed in any preceding claim, wherein a flux control layer is provided on the support.

9. An apparatus as claimed in any one of claims 6 or 7, wherein a flux control layer is provided on a first surface of the support and the layer with a roughened surface is provided on an opposite surface of the support.

10. Apparatus as claimed in claim 8 or 9, wherein the flux control layer comprises an inorganic porous layer which is adapted to hold a portion of the catalyst therein and to control the passage of the first reactant through the membrane.

11. Apparatus as claimed in any one of claims 8 to 10, wherein the flux control layer is selected from the group consisting of silica and gamma alumina.

12. Apparatus as claimed in any preceding claim, wherein the catalyst comprises a metal catalyst.

13. Apparatus as claimed in claim 12, wherein the metal catalyst is selected from the group consisting of rhodium, ruthenium and nickel.

14. Apparatus as claimed in any preceding claim, wherein the membrane is provided in the shape of a cylinder.

15. Apparatus as claimed in any preceding claim, wherein the membrane comprises one or more struts.

16. Apparatus as claimed in any preceding claim, wherein the support comprises alpha alumina.

17. A method of producing hydrogen gas, the method comprising:
providing a membrane, the membrane comprising a support and a catalyst;
passing a first reactant through the membrane from a first chamber to a second chamber;
allowing the first reactant to come into contact with the catalyst upon passage through said membrane;
imparting the first reactant with enough energy so as to react with the second reactant;

reacting the first reactant with a second reactant to produce hydrogen gas.

18. A method as claimed in claim 17, wherein the energy imparted on the first reactant activates molecules of the first reactant without forming an ionic species before the reaction with the second reactant.

19. A method as claimed in claim 17 or 18, wherein the temperature is over 500°C.

20. A method as claimed in claim 19, wherein the temperature is between 700°C and 800°C.

21. A method as claimed in any one of claims 17 to 20, wherein the first reactant is one of oxygen and a hydrocarbon, and the second reactant is the other of oxygen and a hydrocarbon.

22. A method as claimed in claim 21, wherein the oxygen and hydrocarbon do not come into contact with each other until the first reactant has passed through said membrane from the first chamber to the second chamber.

23. A method as claimed in claim 21 or 22, wherein the hydrocarbon comprises a normally gaseous hydrocarbon.

24. A method as claimed in any one of claims 20 to 23, wherein the pressure within the first chamber is greater than the pressure within the second chamber.

25. A method as claimed in any one of claims 20 to 24, wherein carbon monoxide is formed in addition to the hydrogen.

26. A method as claimed in claim 25, wherein the carbon monoxide and hydrogen are further reacted to produce normally liquid hydrocarbons in a Fischer-Tropsch type reaction.

27. A method as claimed in any one of claims 20 to 25, wherein the hydrogen is recovered for use as a fuel.

28. A method of preparing a membrane, the method comprising:
providing a support; and
adding a catalyst to the support.

29. A method as claimed in claim 28, wherein the support is an inorganic support.

30. A method as claimed in claim 28 or 29, further including the step of applying a coating to one of the surfaces of the support.

31. A method as claimed in claim 30, wherein the coating produces a roughened surface on the support, said surface having an increased tortuosity compared to the tortuosity of the rest of the support.

32. A method as claimed in claim 30 or claim 31, wherein the coating comprises a metal oxide or metal oxide precursor.

33. A method as claimed in claim 32, wherein the metal oxide or precursor comprises a group IV metal oxide or group IV metal oxide precursor.

34. A method as claimed in claim 33, wherein the group IV metal oxide or precursor comprises TiO_2 or a TiO_2 precursor.

35. A method as claimed in claim 30, wherein the coating produces a flux control layer on the membrane.

36. A method as claimed in any one of claims 30 to 34, wherein a second coating, the second coating being a flux control layer, is also applied to the support.

37. A method as claimed in claim 35 or 36, wherein the flux control layer is applied to the membrane by exposure to a boemite sol.

38. A method as claimed in any one of claims 28 to 36 wherein the coating and/or the second coating is applied by dipping the support into a liquid comprising the coating.

39. A method as claimed in any one claims 28 to 38, including the step of applying the catalyst to a surface of the membrane by passing a catalyst precursor solution over a first surface of the support and an osmotic solution over the opposite surface of the support, and allowing the catalyst or a catalyst precursor to be deposited on the support via the process of osmosis.

40. A method as claimed in any one of claims 28 to 39, further including the steps of drying the support and heating/firing the support.